Surface Water Quality Evaluation Using Expert's Opinion

Kosha A. Shah
Assistant Professor,
Deptt.of Civil Engineering
F T E The M.S. University of Baroda, Vadodara,
Gujarat

Abstract

Surface water quality can be affected by various activities: natural and man made. More obvious are the polluting activities, such as the discharge of domestic, industrial, urban and other wastewaters into the watercourse (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin. Water quality is affected largely by uncontrolled land use for urbanisation or deforestation, accidental (or unauthorised) release of chemical substances, discharge of untreated wastes or leaching of noxious liquids from solid waste deposits. Similarly, the uncontrolled and excessive use of fertilisers and pesticides has long-term effects on ground and surface water resources (Chapman,1996). In this paper, an attempt has been made to develop a Water Quality Index using expert's opinion to assess the quality of water in Sabarmati river and its tributary at two different locations.

Keywords: Water Quality, Experts' Opinion, Water Quality Index.

Introduction

Cities in developing countries are growing the fastest (UNEP). Urbanization affects the water quality. The surface water bodies are under a continuous threat due to growth of urbanization and industrialization. As urbanization increases, water quality is impaired due to the high anthropogenic activities, illegal discharge of sewage and industrial effluent, lack of proper sanitation, unprotected river sites and urban runoff .Thereby, the surface water is unable to support a human use, such as drinking water, or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish. Different water quality parameters cannot give a composite idea about the water quality. Hence, a water quality index is developed to aggregate There is a need to develop a Water Quality Index for assessing surface water quality.

Study Area

The Sabarmati river was branded as the third most polluted river in the country by the Central Pollution Control board (CPCB) in 2010. Comptroller and Auditor General (CAG) reported in 2012."Present status of Sabarmati shows the presence of faecal-related disease causing pathogens as well as organic pollution at the outskirts of the city limits". In another study conducted by the LD Engineering College in 2012, it was found that the river was unfit for aquatic life with its dissolved oxygen being zero, even 28 km downstream. The water quality is evaluated at two locations along a stretch of Sabarmati river and its tributary:

1. Sabarmati river at V.N. Bridge, at Ahmedabad city located in Ahmedabad district and
2. Shedhi tributary of Sabarmati river at Kheda city located in Kheda district.

Aim of the Study

The aim of the paper is to use opinion of experts' to derive weightages of various parameters of water quality and then to compute Water Quality Index. The results show that water quality at Ahmedabad is poor compared to Shedhi river tributary as the Water Quality Index is lower at Ahmedabad than at Kheda.

Methodology

Selection of parameters for Water Quality Index model formulation

The data are collected for various parameters, such as pH, Dissolved oxygen, BOD, Electrical Conductivity, Nitrate nitrogen and Total Coliform for these river locations on Sabarmati river and its tributary.

Effect of pH

The pH is a measure of the acidic or alkaline conditions of the water. When the water is used for drinking purpose, the pH level of the water has an important effect on all body chemistry, health and disease because human body consists of 50–60 % water. The pH level of our body fluid should be in the range 7–7.2. If pH is less than 5.3, assimilation of vitamins or minerals is not possible; hence, it should be above 6.4. If pH is greater than 8.5, causes the water taste bitter or soda-like taste. If the pH is greater than 11,causes eye irritation and exacerbation of skin disorder. pH in the range of 10–12.5 cause hair fibers to swell. pH in the range 3.5–4.5 affects the fish reproduction.(Avvanavar and Shrihari 2008; Leo and Dekkar 2000).

Effect of Dissolved Oxygen

The amount of DO present in surface waters depends on water temperature, turbulence, salinity, and altitude Natural waters in equilibrium with the atmosphere will contain DO concentrations ranging from about 5 to 14.5 mg O2 per liter. The DO concentration present in water reflects atmospheric dissolution, as well as autotrophic and heterotrophic processes that, respectively, produce and consume oxygen. DO is the factor that determines whether biological changes are brought by aerobic or anaerobic organisms. Thus, dissolved–oxygen measurement is vital for maintaining aerobic treatment processes intended to purify domestic and industrial wastewaters. A rapid fall in the DO indicates a high organic pollution in the river. The optimum value for good water quality is 4 to 6 mg/l of DO, which ensures healthy aquatic life in a water body (Sawyer et al. 1994; Leo and Dekkar 2000; Burden et al. 2002; De 2003).

Effect of biological Oxygen demand

Biochemical oxygen demand (BOD) determines the strength in terms of oxygen required to stabilize domestic and industrial wastes. For the degradation of oxidizable organic matter to take place minimum of 2–7 mg/l of DO level is to be maintained at laboratory experimentation or should be available in the natural waters (De 2003).

Effect of total dissolved solids/electrical conductivity

Total dissolved solids (TDS) is the amount of dissolved solids (i.e., salts) in the water. TDS can be measured indirectly by measuring the EC. The more dissolved salts in the water, the more electricity the water will conduct. EC is the ability of the water to conduct an electrical current. Conductivity is important because it directly affects the quality of the water used for drinking and irrigation. Waters with higher solids content have laxative and sometimes the reverse effect upon people whose bodies are not adjusted to them and cause the water to have an unpleasant mineral taste. TDS consists of oxygen-demanding wastes, disease-causing agents, which can cause immense harm to public health. The presence of synthetic organic chemicals (fuels, detergents, paints, solvents, etc) imparts objectionable and offensive tastes, odors and colors to fish and aquatic plants even when they are present in low concentrations (Leo and Dekkar 2000). Dissolved ions affect the pH of water, which in turn may influence the health of aquatic species.

Effect of Nitrate Nitrogen

Excess nitrate nitrogen can cause eutrophication of surface waters due to over stimulation of growth of aquatic plants and algae. It causes anaerobic conditions in the water bodies leading to fish kills, and can even ‘‘kill’’ a lake by depriving it of oxygen. High levels of Nitrate nitrogen can cause the respiration efficiency of fish and aquatic invertebrates to lower down, leading to a decrease in animal and plant diversity, and affects use of the water for fishing, swimming, and boating. High levels of Nitrate nitrogen in water can cause serioushealth hazards. The acute health hazard associated with drinking water with elevated levels of nitrate occurs when bacteria in the digestive system transform nitrate to nitrite. The nitrite reacts with iron in the hemoglobin of red blood cells to form methemoglobin, which lacks the oxygen carrying ability of hemoglobin. This creates the condition known as methemoglobinemia (sometimes referred to as ‘‘blue baby syndrome’’), in which blood lacks the ability to carry sufficient oxygen to the individual body cells. Infants under 1 year of age have the highest risk of developing methemoglobinemia from consuming water with elevated levels of nitrate.

Effect of Micro–organisms

The most common risk to human health associated with water stems from the presence of disease-causing micro-organisms. Many of these microorganisms originate from water polluted with human excrement. Human faeces can contain a variety of intestinal pathogens which cause diseases ranging from mild gastro-enteritis to the serious, and possibly fatal, dysentery, cholera and typhoid. Contamination of water bodies by animal or human excrement introduces the risk of infection to those who use the water for drinking, food preparation, personal hygiene and even recreation. (Chapman, 1996).

Development of Rating Scale

A Rating scale was prepared for range of values for each parameter. The rating value varies from 0 to 100 and is divided into five classes in this study. The rating value (Vr) = 0 implies that the concentration of the parameter in water is exceeded by the standard maximum permissible limits and water is considered to be severely polluted. The rating value (Vr) = 100 denotes the excellent water quality since the parameter remained well within the prescribed permissible limit for drinking water and water is clean. The other ratings are considered to fall between these two extremities and are Vr = 40, Vr = 60, and Vr = 80 standing for excessively polluted, moderately polluted and slightly polluted respectively. Table 1 shows the rating scale developed.

Parameters	Range				
Class	1	2	3	4	5
pH	7-8.5	8.5-8.6 6.8-7.0	8.6-8.8 6.7-6.8	8.8-9.0 6.5-6.7	>9.0 <6.5
DO (mg/l)	>6	5.0-6	4.0-5	3.0-4	<3
BOD (mg/l)	0-3	3.0-6	6.0-80	80.0-125	>125
Electrical conductivity (micromhos/cm)	0-75	75-150	150-225	225-300	>300
Nitrate Nitrogen (mg/l)	0-20	20.0-50	50.0-100	100-200	>200
Total Coliform MPN/100 ml	0-5	5.0-50	50-500	500-10000	>10000
Extent of pollution	Clean	Slight	Moderate	Excess	Severe
Vr	100	80	60	40	0

Estimating the weighing factor of each indicator parameter (Wi)

The weightage of each parameter is evaluated using Delphi Technique (A structured process for collecting knowledge from experts), (Linston and Turoff, 1975).A total of 6 water quality scientists/experts have been interviewed for various water quality parameters and asked them for relative ranking for six indicator water quality parameters under study. The weightage for each parameter [Wi] is calculated with the help of relative rank for its importance in water quality opined by water quality experts. Table 2 shows the Weightage obtained for water quality parameters using experts opinion.

Table 2 Computation of weightage of water quality parameters using experts opinion

Parameter	Relative Rank						Sum	Normalized sum	Weightage (W_i)
	Expert-1	Expert-2	Expert-3	Expert-4	Expert-5	Expert-6			
pH	6	5	5	6	6	6	34	16.11	0.16
DO	9	9	9	9	8	9	53	25.12	0.25
BOD	8	8	8	8	8	8	48	22.75	0.23
Electrical conductivity	1	2	1	1	1	1	7	3.32	0.03
Nitrate nitrogen	3	3	3	2	2	3	16	7.58	0.08
Total coliform	9	9	9	8	9	9	53	25.12	0.25
Note: 9- most important, 1- least important						**Total**	211		

Water Quality Index (WQI) by Delphi Technique

Water Quality Index is equal to the sum of product of rating (Vr_i) and weightage (W_i) for all the parameters.

$$WQI = \sum_{i=1}^{n} (W_i \, \mathrm{x} Vr_i)$$

Results

The water quality index is calculated for the two locations on Sabarmati river and its tributaries.

The results of Water Quality index are shown in table 3.

Table 3 Water Quality Index for the stations computed using Delphi technique

Water Quality Index									
Location 1 Sabarmati river at V. N Bridge, Ahmedabad district									
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Avg.**	**Grand Avg.**
Jan	47.8	24.0	62.8	63.8	47.8	57.0	37.8	48.71	51.54
Apr	30.0	33.2	25.8	47.8	34.0	33.2	43.2	35.31	
July	37.8	57.8	72.8	37.8	62.8	33.2	47.8	50	
Oct	72.4	67.8	72.8	67.0	73.8	67.8	83.2	72.11	
Location 2 Shedhi tributary of Sabarmati, Kheda district									
	2005	2006	2007	2008	2009	2010	2011	Avg.	
Jan	62.4	82.0	82.4	87.0	87.4	87.4	92.0	82.94	76.49
Apr	62.8	77.4	82.4	87.4	52.8	57.8	84.2	72.11	
July	68.8	52.8	62.8	67.8	92.0	77.8	71.4	70.49	
Oct	64.2	82.0	77.4	77.8	87.0	92.0	82.4	80.40	

Conclusions

Water Quality Index is a single score determining the quality of water. A lower value of Water Quality index indicates poor water quality whereas higher Water Quality Index indicates a good water quality. It is observed from table 3 that Water quality of location 1 i.e, Sabarmati river at Ahmedabad is poor (51.54) compared to location 2 i.e Shedhi tributary of Sabarmati river at Kheda (76.49). Table 3 also shows the seasonal variation of water quality index. At location 1, the water quality is poorest in the summer (35.31) followed by winter (48.71), monsoon

(50) and post monsoon (72.11). At location 2, the water quality is poorest in monsoon (70.49), followed by summer (72.11), post monsoon (80.40) and winter (82.94).

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